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FABRICATION OF ELECTROPORCELAIN ON THE BASIS OF RAW MATERIALS FROM THE AMUR REGION

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A mineralogical and chemical analysis of kaolin-feldspar raw material from the Chalganov deposit is performed. Experimental samples of electrotechnical porcelain have been obtained and their electrophysical and mechanical properties have been investigated.

The most commonly used electric insulation material in the electrotechnical industry is electrotechnical porcelain. This is because this material possesses good operating properties and the raw material for manufacturing it is comparatively inexpensive. The production of electrotechnical porcelain is based predominately on natural raw materials. Traditionally, electrotechnical porcelain was produced in the western regions of Russia, but substantial resources of mineral raw materials suitable for producing ordinary ceramics as well as electrotechnical porcelain are present even in the Amur region [1].

Sands containing kaolin, quartz, and feldspar, deposits of which are located in direct proximity to the village of Chalgan, can be used as raw material for the production of electrotechnical porcelain in the Amur region. The total explored raw-material reserves amount to about 190 million metric tons and include the following (10^6 tons): kaolin — 28,197, quartz sand — 52,868, feldspar — 7049. The Amur Science Center has a license to extract and refine kaolin-bearing sands.

The enrichment of kaolins from the Chalgan deposit is based on the separation of mineral components of the raw materials according to their coarseness. Highly disperse grains of kaolinite are separated from large grains of minerals in flowing water. Enrichment yields two products: a kaolin concentrate and quartz-feldspar raw material. The chemical composition of the kaolin fraction of the Chalgan deposit is comparatively constant. The sand washed from the kaolin consists of a quartz-feldspar mixture. The quartz and feldspar contents are 83 – 88%[2] and 8 – 10%, respectively. We note that such an amount of feldspar is inadequate for the production of electrotechnical porcelain. However, sieving the sand makes it possible to increase the content of feldspars. Thus, the content of feldspars in the sand fraction smaller than 0.4 mm increases to 25 – 35%.

Table 1 presents the chemical composition of the kaolin and quartz-feldspar concentrate. Preliminary mineralogical and x-ray phase analysis of the samples before comminution showed the presence in the quartz-feldspar raw material of the following (%): 14.0 microcline, 39.0 quartz, 45.5 quartz-feldspar concretions, 1.6 mica. In addition, quartz-feldspar concentrate also contains ilmenite, magnetite, and muscovite.

We attempted to make samples of electrotechnical porcelain from the Chalgan raw material that would meet government standards. The possibility of doing this was previously examined theoretically [2]. The technological process of electroporcelain production consisted of several stages:

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[2] Here and below — content by weight.

TABLE 1.

Concentrate	Content, wt.%							
	SiO_2	Fe_2O_3	TiO_2	Al_2O_3	K_2O	Na_2O	CaO	MgO
Quartz-feldspar	66.60	0.28	0.66	18.61	11.55	0.38	0.16	0.01
Kaolin	49.00 – 51.00	0.70 – 1.20	0.30 – 0.50	34.00 – 35.00	1.00 – 1.50	0.10 – 1.50	0.25	0.10 – 0.25

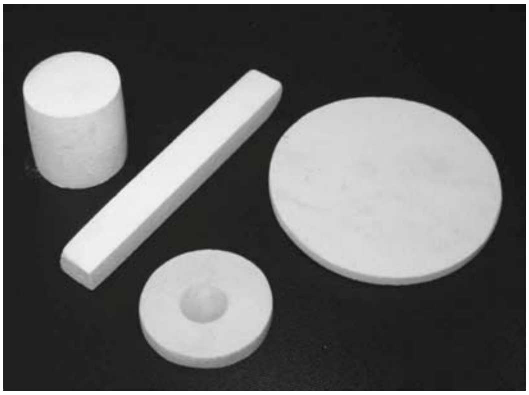

Fig. 1. Ceramic samples for investigating the electrophysical and mechanical properties.

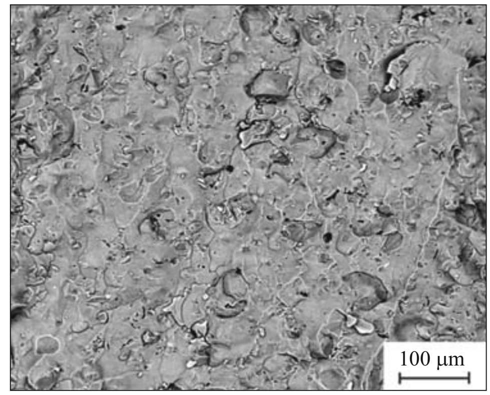

Fig. 2. Electron-microscopic photograph of a cleavage surface of a porcelain sample.

preparation, comminution, and mixing of the initial raw materials in the required proportions;

formation of an article with the required shape from powder (mix);

heat-treatment (sintering).

The samples obtained consisted of 35 and 17 mm in diameter and 1 – 3 mm thick disks, 50 – 70 mm high prisms with cross-section 5 × 5 mm, and approximately 15 mm high and 10 mm in diameter cylinders (Fig. 1).

After preliminary purification in a magnetic field the initial material (quartz-feldspar concentrate) was pre-sintered at 900 – 1000°C in an oxidative medium in order to improve their comminution as a result of the polymorphous transformation of quartz. To ensure fine comminution, nonplastic materials were comminuted first. Then clayey materials are added to the latter and the components were additional comminuted together. The milling bodies were uralite spheres. The fineness of the comminution, which was no more than 1.5%, was monitored according to the residue on a No. 006 sieve. The obtained dry mass, which contained a clayey component, was dispersed in a mixer and carefully mixed. The slip prepared was subjected to dehydration to 25 – 30%.

Compression molding in a metal mold was used to form samples with a prescribed shape. After drying the mold, the samples were sintered in three stages: the first one was calcination to remove free water in an oxidative atmosphere at a temperature close to 300°C; the second one was calcination in a reducing medium to temperature 1100°C; the third, and final, one was calcination in an oxidative medium. The maximum calcination temperatures were 1200, 1300, and 1400°C. The optimal calcination temperature was chosen so that the finished article would possess maximum strength.

The main physical – mechanical and electrical properties of the material obtained are presented in Table 2. Small discrepancies could be due to methodological differences (type and shape of the article, testing method, and others) [3 – 5].

X-ray structural analysis showed the presence of mullite, separated quartz, and a glassy phase in the samples. On the basis of the data from silicate analysis, the computed composition of the porcelain calcined at 1300°C includes the following (%): 29.3 mullite, 11.9 quartz, 58.8 glassy phase [4], which agrees quite well with x-ray phase analysis. A typical picture of a cleaved surface of a sample is displayed in Fig. 2.

The samples obtained from a mixture of 55% kaolin and 45% quartz concentrates possess a color which is characteristic for porcelain. A magenta check of the samples for open porosity showed that their porosity is negligible. The appa-

TABLE 2.

Samples	Ultimate strength, MPa		Electric strength, kV/mm	Tangent of dielectric loss angle at 50 Hz	Permittivity	Resistivity, $\Omega \cdot m$
	under compression	under static bending				
Articles*:						
group 1	–	60.0	30	≤ 0.030	–	$\geq 10^{10}$
group 2	–	80.0	30	≤ 0.025	–	$\geq 10^{11}$
group 3	–	110.0	30	≤ 0.025	–	$\geq 10^{11}$
F1 (based on kaolin from the Chalganskoe deposit)	250	51.8	> 15	0.021	8.7	5.1×10^{11}

* In accordance with the industry norm OAA-643.001–69.

rent density was about 2.13 g/cm^3 and the apparent porosity is 1.6%.

The electrical and mechanical properties of the samples were determined beforehand. The room-temperature permittivity at 100 Hz is 8.7, the tangent of the dielectric loss angle is 0.021, and the resistivity is 5.1×10^{11} $\Omega \cdot$ m (see Table 2). It should be noted that these values agree quite well with the data for commercially produced insulators [5].

The ultimate bending and compression strength of the samples were determined by the GOST 24409–80 procedure. The highest bending strength (51.8 MPa) was observed for samples calcined at 1300°C.

The data obtained show that kaolin from the Chalgan deposit (Amur region) is quite suitable for fabricating electrotechnical porcelain.

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